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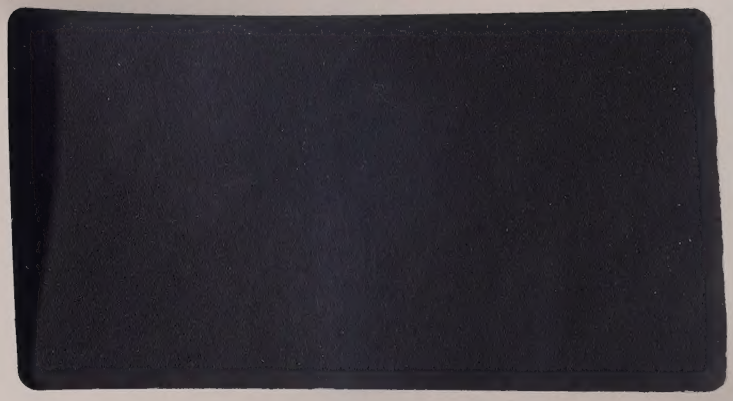
INSTRUCTION MANUAL

EMPIRE

BROADBAND DIPOLE ANTENNA

MODEL MD-105-T1

SINGER
INSTRUMENTATION



INSTRUCTION MANUAL

EMPIRE*

BROADBAND DIPOLE ANTENNA

MODEL MD-105-T1

Instruction Manual No. 110-5014

Gertsch*
EMPIRE*
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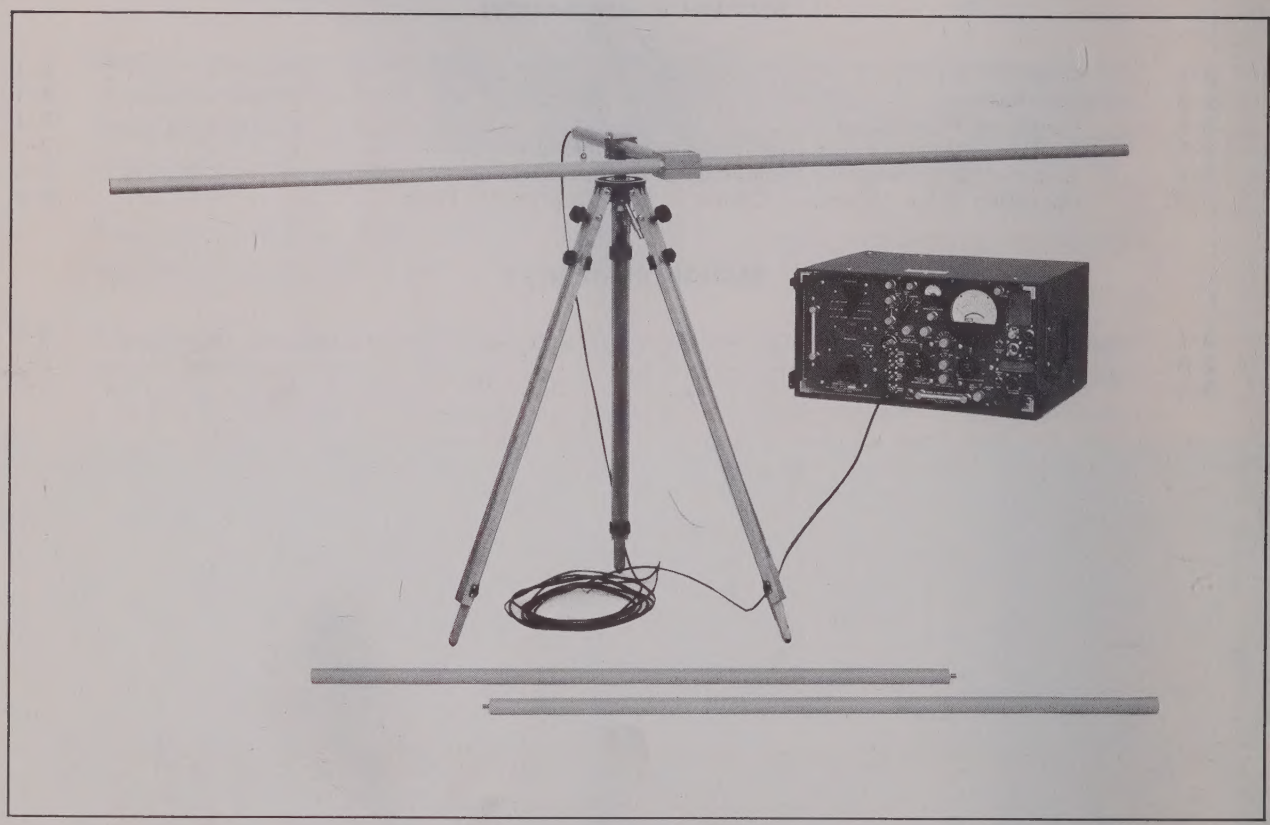


Figure 1-1. Model MD-105-T1 Broadband Dipole Antenna (Shown Connected to Model NF-105 Noise and Field Intensity Meter)

SECTION I

INTRODUCTION

1-1. SCOPE OF MANUAL.

1-2. This manual contains instructions for the use of the Model MD-105-T1 Broadband Dipole Antenna manufactured by THE SINGER COMPANY, Metrics Division, Bridgeport, Connecticut. The manual includes description, operating instructions, theory, and installation procedures. See figure 1-1.

1-3. PURPOSE AND USE OF THE EQUIPMENT.

The Model MD-105-T1 Broadband Dipole Antenna is intended as a replacement of the tuned resonant dipole antenna for making radiated measurements. It covers the frequency range of 20 MHz to 200 MHz with a single setting of the dipole's length, thus eliminating one difficulty towards achieving fast frequency scan measurements. The performance (output voltage vs. field intensity) of the broadband dipole is essentially equal to that of the resonant dipole. The broadband dipole antenna meets the requirements of USAF Specification MIL-STD-826. It will operate with the Noise and Field Intensity Meters manufactured by THE SINGER COMPANY, Metrics Division such as; NF-105, NF-105F and NF-205 or with any instrument having a 50-ohm input impedance.

1-4. The Model MD-105-T1 Broadband Dipole Antenna consists of a carrying case containing a boom, mounting clamp, and four dipole elements. The antenna with short elements (overall length 74.5 inches) is fixed tuned to 75 MHz, and operates over the entire frequency range. With the long elements added to the short elements (overall length 162.5 inches), the antenna is fixed tuned to 35 MHz and operates over the frequency range of 20 MHz to 65 MHz.

Figure 1-2 shows the carrying case containing the boom, mounting clamp, and the four dipole elements. The boom has a block at one end containing two threaded inserts for attaching the short dipole elements. The long elements attach to the opposite end of the short elements. The other end of the boom has a BNC female connector for mating with the CB-105 coaxial 30 foot cable. The mounting clamp is used to attach the boom to Tripod TP-105A.

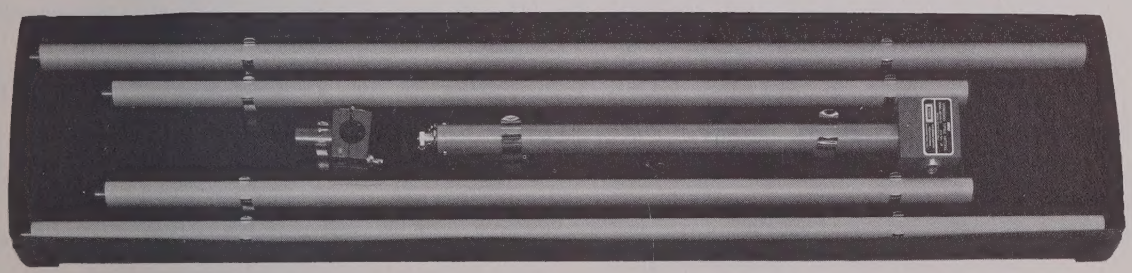


Figure 1-2. Broadband Dipole Antenna with Carrying Case

The height of the antenna is adjustable by means of the antenna masts MA-105 and antenna socket MS-105. All items noted above are standard accessories.

1-5. SPECIFICATIONS.

Antenna Type	Dipole (fixed tuned)
Frequency Range	20 MHz to 200 MHz
Output Impedance	Operates into a 50 ohm load
Antenna Factor	See figure 2-1
Maximum Field Intensity	10 volts per meter
Maximum Input to BNC Terminal	2 watts

SENSITIVITY (RADIATED MEASUREMENT)

The MD-105-T1 broadband dipole antenna when used in conjunction with the NF-105 series of Noise and Field Intensity Meters under a signal plus noise to noise ratio of 6db per MIL-STD-826 produces the following sensitivities.

Freq. In MHz	Antenna Lengths In Inches	CW Sensitivity DBue/Meter	Impulse Sensitivity DBMC/Meter
25 25	162.5 74.5	9 22	32 45
35 35	162.5 74.5	10 22	33 45
65	74.5	16	38
200	74.5	27	50

Dimensions:

Case	46 in. x 11 in. x 2 in.
Boom	1-1/8 in. dia x 21-1/2 in.
Short Elements (2 ea)	1 in. dia x 26-1/2 in. long
Long Element (2 ea)	1 in. x 44 in. long
Weight (with case)	approximately 10 lbs.

SECTION II
OPERATION

2-1. GENERAL.

2-2. The Model MD-105-T1 Broadband Dipole Antenna operates with the Model NF-105 and Model NF-205 Noise and Field Intensity Meter series or similar equipment having an input impedance of 50 ohms. Basic measurement procedures are stated in applicable operating instructions of the appropriate unit.

The Model MD-105-T1 is shipped in a custom fitted case which contains all the components necessary to assemble and use the instrument. No special instructions are necessary other than those stated in the following installation paragraphs. See figure 1-2.

2-3. INSTALLATION.

2-4. The broadband dipole antenna (overall length 74.5 inches) covering the frequency range from 20 MHz to 200 MHz is assembled as follows:

1. Remove Tripod TP-105 from Tripod Bag. Loosen the three lower clamps and extend inside members to the desired length. Tighten lower clamps.

2. Loosen the three upper clamps and separate legs equally so that the top locking screw plate is level to the horizontal plane. Tighten upper clamps and set tripod securely on the ground.

3. Set Mast Socket MS-105 on top of tripod locking screw plate.

4. Remove the boom, mounting clamp, and two each of the short dipole elements from the case.

5. Screw the mounting clamp onto mast socket with tripod locking screw.

6. Thread the short dipole elements into the inserts located at the block end of the boom.

7. Unhinge the hasp on the mounting clamp.

8. Set the boom in the mounting clamp with approximately one-third of the connector end of the boom extending beyond the mounting clamp. The antenna polarization is changed by rotating the boom in the mounting clamp.

9. Tighten the mounting clamp.

10. Attach one end of the Input Cable CB-105 to the output BNC connector on the antenna boom. Attach the other end to the signal input connector on the field intensity meter.

11. The antenna is now set up for measurements in the frequency range from 20 MHz to 200 MHz.

2-5. The broadband dipole antenna (overall length 162.5 inches) covering the frequency range from 20 MHz to 65 MHz is assembled as follows:

1. Repeat steps 1 through 8 in paragraph 2-4.

2. Set the antenna in the horizontal plane.

3. Remove the long dipole elements from the case and attach them to the ends of the short elements.

4. The antenna is now horizontally polarized for measurements in the frequency range from 20 MHz to 65 MHz.

5. For vertical polarization, the antenna must be elevated in order for the dipole to clear the ground.

The height of the antenna is raised by inserting three masts sections MA-105 between the mast socket, MS-105 placed on the Tripod and the mounting clamp placed on the boom of the antenna.

2-6. OPERATING PROCEDURES.

2-7. RADIATED MEASUREMENTS PERFORMED IN A SHIELDED ENCLOSURE.

To perform radiated measurements in a shielded enclosure with the Model MD-105-T1 Broadband Dipole Antenna, proceed as follows:

1. Assemble the antenna with short dipole elements (overall length 74.5 inches) for measurement in the frequency range from 20 MHz to 200 MHz. Refer to paragraph 2-4.

Where greater sensitivity is required at the low frequency end, the long dipole elements are added to the short elements (overall length 162.5

inches), making the operating range of the antenna 20 MHz to 65 MHz. Refer to paragraph 2-5 for assembly procedure.

2. Where measurements are made in accordance with published specifications, set up system equipment as indicated in the applicable document. Under other conditions, set the antenna in the horizontal plane approximately three feet from the test sample.

3. Calibrate the Noise and Field Intensity Meter and measure the two terminal voltage from the antenna in DB above one microvolt.

4. The field strength in DB above one microvolt per meter is obtained by adding the antenna factor derived from figure 2-1 to the two terminal voltage reading in step 3.

NOTE

In figure 2-1, the antenna factors for the antenna using the short dipole elements (overall length 74.5 inches) are indicated by the solid line. The antenna factors for the antenna using the long dipole elements added to the short dipole elements (overall length 162.5 inches) are indicated by the dashed line.

2-8. RADIATED MEASUREMENTS PERFORMED IN THE FAR FIELD.

To measure a single radiated signal at any specific frequency, proceed as follows:

1. Repeat paragraph 2-7, step 1.

2. Alternately set the antenna in both the vertical and horizontal planes and note the meter deflection on the field intensity meter for each position.

3. Set or leave the antenna in the position which produces the greatest deflection on the indicating meter.

4. If the position in step 3 is vertical, no azimuth orientation is required. If the antenna position is horizontal, loosen locking screw on the tripod and rotate the antenna for a maximum meter deflection on the Noise and Field Intensity Meter.

5. Calibrate the Noise and Field Intensity Meter and measure the two terminal voltage from the antenna in DB above one microvolt.

6. The field strength in DB above one microvolt per meter is obtained by adding the antenna factor derived from figure 2-1 to the two terminal voltage reading in step 5.

2-9. When measuring radiated signals over a wide frequency range, the polarization and directivity of the various signals will change. Therefore, since no single position of the antenna can be specified, the antenna should be positioned as follows and a complete scan made for each antenna position.

1. Vertical polarization.

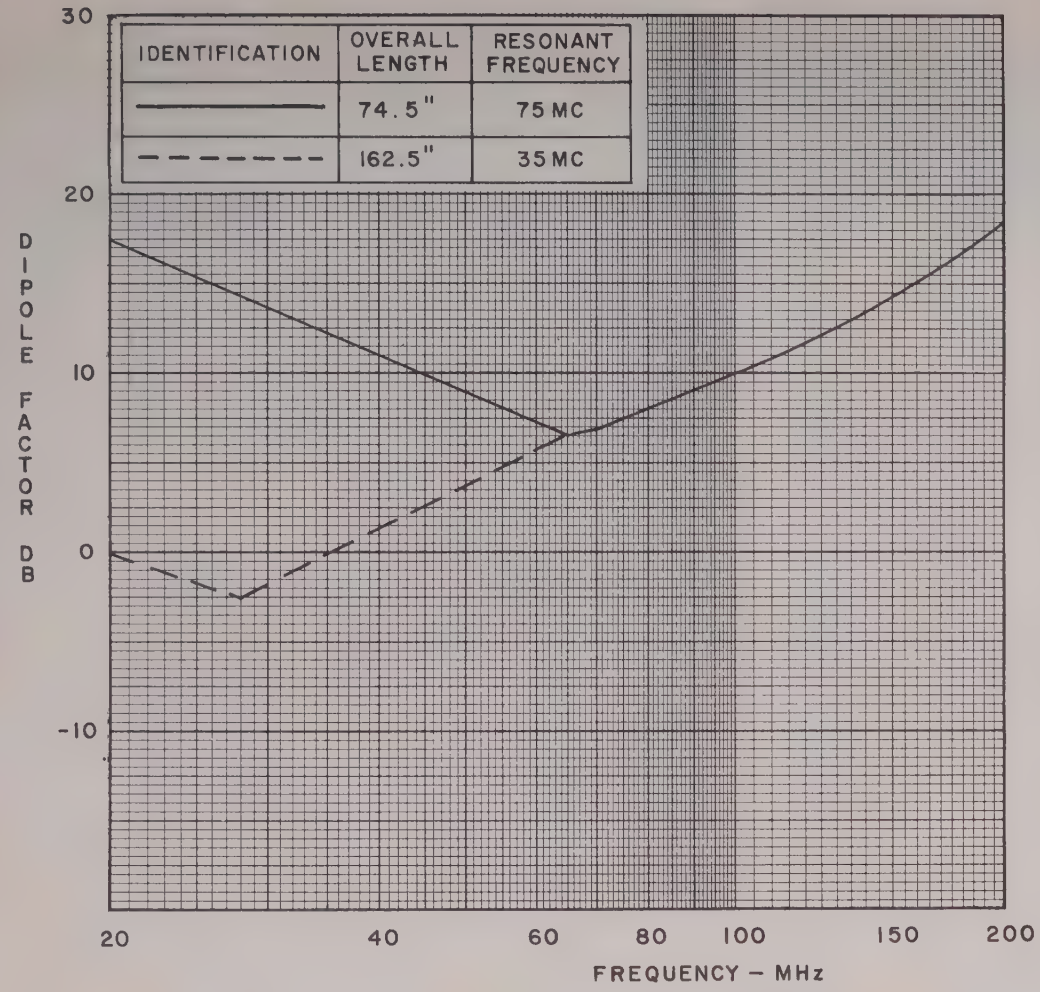
2. Horizontal polarization in an arbitrary azimuth direction.

3. Horizontal polarization with the antenna rotated clockwise 45 degrees from the position in step 2.

4. Horizontal polarization with the antenna rotated clockwise 45 degrees from the position in step 3.

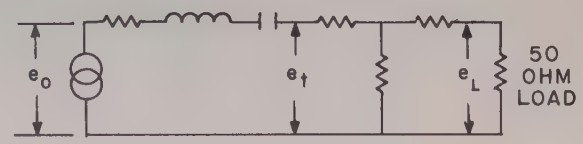
2-10. OPERATION OF THE ANTENNA TO CREATE AN ELECTROMAGNETIC FIELD.

The Broadband Dipole Antenna may be used as a radiator of electromagnetic energy by feeding a signal source into the BNC terminal. The operating frequency range is 20 MHz to 200 MHz and the maximum power input is two watts.



ANTENNA INTERNAL IMPEDANCE

ATTENUATION IN 30FT OF RG-55/U CABLE



(1) $A_f = 20 \log \frac{1}{h_e} + 20 \log \frac{e_o}{e_t} + 20 \log \frac{e_t}{e_L}$

where A_f = ANTENNA FACTOR IN DB

h_e = EFFECTIVE HEIGHT IN METERS.

e_o = ANTENNA INDUCED OPEN CIRCUIT MICROVOLTS.

e_t = VOLTAGE AT ANTENNA TERMINAL.

e_L = VOLTAGE ACROSS THE 50 OHM LOAD.

(2) $F_s = e_L + A_f$ = FIELD STRENGTH in DB above one microvolt per meter.

Figure 2-1. Antenna Factor for Model MD-105-T1 Broadband Dipole Antenna

SECTION III
THEORY

3-1. INTRODUCTION.

3-2. The present goal in all EMC measurements is to scan over as wide a frequency range as possible and to record the results, as an X-Y plot, in the shortest time possible. The biggest drawback to the time element is the requirement that the present dipole antenna be tuned for each measurement frequency. To eliminate this time consuming operation, the broadband dipole antenna was developed. This antenna when fixed tuned to 75 MHz (overall length 74.5 inches) covers the entire range of 20 MHz to 200 MHz without further adjustments. When used with the NF-105 Noise and Field Intensity Meter series, it will respond to radiated signals with sufficient sensitivity to operate under the radiated limits specified in MIL-STD-826.

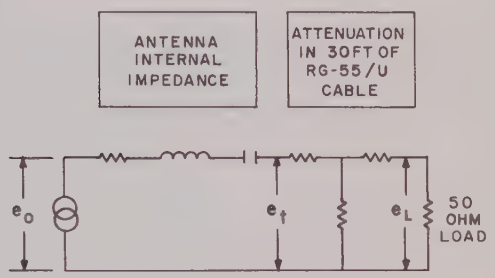
3-3. DESIGN CRITERIA.

3-4. The factors considered in the design of the broadband dipole antenna are polarization, antenna factor, and antenna pattern.

3-5. Polarization orientation is required on dipole antennas and cannot be avoided. When scanning over a large frequency range, the correct procedure is to make two scans. Once with the antenna in a vertical plane and again with the antenna in a horizontal plane.

3-6. Antenna pattern of a resonant half-wave dipole antenna has two major lobes. This causes no confusion since the two lobes are identical and 180 degrees apart. However, when the antenna is operated at frequencies which correspond to antenna lengths greater than one wavelength, minor lobes begin to appear. When the antenna length reaches 1.5 wavelengths, many lobes appear, but in particular there is a shift in the direction of the major lobe. This, therefore is one limitation placed on the frequency coverage of a broadband dipole antenna. However, the MD-105-T1, when receiving a 200 MHz signal operates at only 1.25 wavelengths where the major lobe is unchanged in direction. The far field pattern for the broadband antenna (overall length 74.5 in.) operating at 200 MHz is shown in figure 3-1.

3-7. Antenna factor relates the field intensity of a wave in space to the output voltage developed by the antenna (across a 50 ohm load) when immersed in the field. The equivalent circuit of the antenna, coaxial connecting cable, and 50 ohm load impedance is shown below.



Field strength equals the antenna induced open circuit voltage divided by the effective height.

(1) $E_s = \frac{e_o}{h_e}$ in microvolts per meter

where e_o = antenna induced open circuit microvolts

h_e = effective height in meters

Since the noise and field intensity meter measures the loaded voltage (e_L), the equation is rewritten as follows:

(2) $E_s = e_L \left[\frac{1}{h_e} \times \frac{e_o}{e_t} \times \frac{e_t}{e_L} \right]$

where e_L = voltage across the 50 ohm load

e_t = voltage at antenna terminal

The term in brackets constitutes the antenna factor ratio. It is composed of the effective height (h_e), the attenuation due to the antenna internal impedance (e_o/e_t) and the attenuation, due to the losses in the 30 ft. connecting cable e_t/e_L. Equation (3) represents the antenna factor (A_f) in DB.

(3) $A_f = 20 \log \frac{1}{h_e} + 20 \log \frac{e_o}{e_t} + 20 \log \frac{e_t}{e_L}$

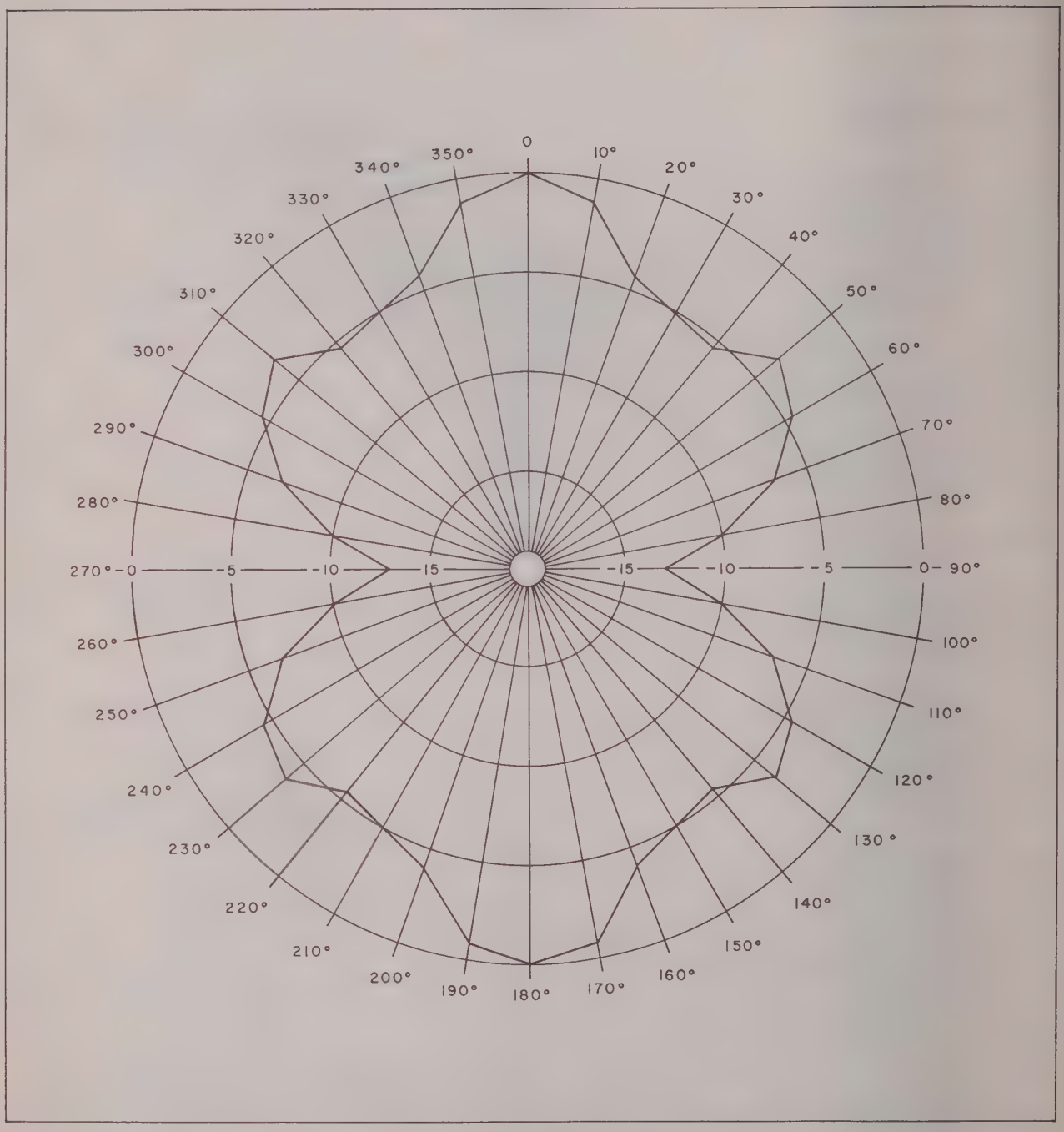


Figure 3-1. Model MD-105-T1 Far Field Pattern (Overall Length 74.5") Operating at 200 MHz

The effective height (h_e) for a half-wave dipole is $\frac{\lambda}{\pi}$ in meters.

Since calculations are more readily made using DB's, equation (2) may be rewritten as follows:

(4) $F_s = e_L + A_f$

where F_s = FIELD STRENGTH in DB above one microvolt per meter

e_L = VOLTAGE ACROSS 50 ohm load in DB above one microvolt

A_f = ANTENNA FACTOR IN DB

The Noise and Field Intensity Meter measures the output of the antenna in DB above one microvolt. The field intensity, in DB above one microvolt per meter, is obtained by adding the antenna factor to the antenna output voltage. Thus the lower the antenna factor, the greater the sensitivity of the ECM measurement system. The broadband antenna, when set to operate over the 20 MHz to 65 MHz range and when reset to operate over the 65 MHz to 200 MHz range provides antenna factors which are essentially equal to that of the resonant dipole antenna. This goal was achieved by making the dipole elements long and of large diameter and improving the impedance match with the balun transformer. The balun transformer is primarily required to couple the balanced voltage developed by the dipole antenna to a single ended coaxial line. It also is made step down (impedance ratio 4 to 1), thus achieving an optimum impedance match into a 50 ohm load from an antenna whose impedance ranges from approximately 30 ohms to as high as 800 ohms. The balun transformer uses a ferrite toroidal core and a winding configuration which is a transmission line. In conventional transformers the interwinding capacitance resonates with the leakage inductance producing losses which limit the high frequency response. In transmission line transformers, the coils are so arranged that the interwinding capacity is the component of the characteristic impedance of the line, and as such forms no resonances which seriously limit the bandwidth.

3-8. PERFORMANCE.

3-9. The performance of the Broadband Dipole Antenna was measured in a far field by the substitution method. That is, the output voltage of the broadband antenna was compared to the output voltage of the resonant antenna using a NF-105 Noise and Field Intensity Meter.

This test supplied the data for the MD-105-T1 antenna factor chart as shown in figure 2-1. Comparison of the antenna factors of the two antennas shows that they are within one db of each other from 20 MHz to 150 MHz. Above 150 MHz the antenna factor for the broadband dipole increases at a greater rate than the antenna factor for the resonant dipole. At 200 MHz, the antenna factor for the broadband antenna is 2.5 db higher than that of the resonant antenna. This relatively small decrease in antenna efficiency is more than compensated by the advantages obtained from the ease and speed of operation.